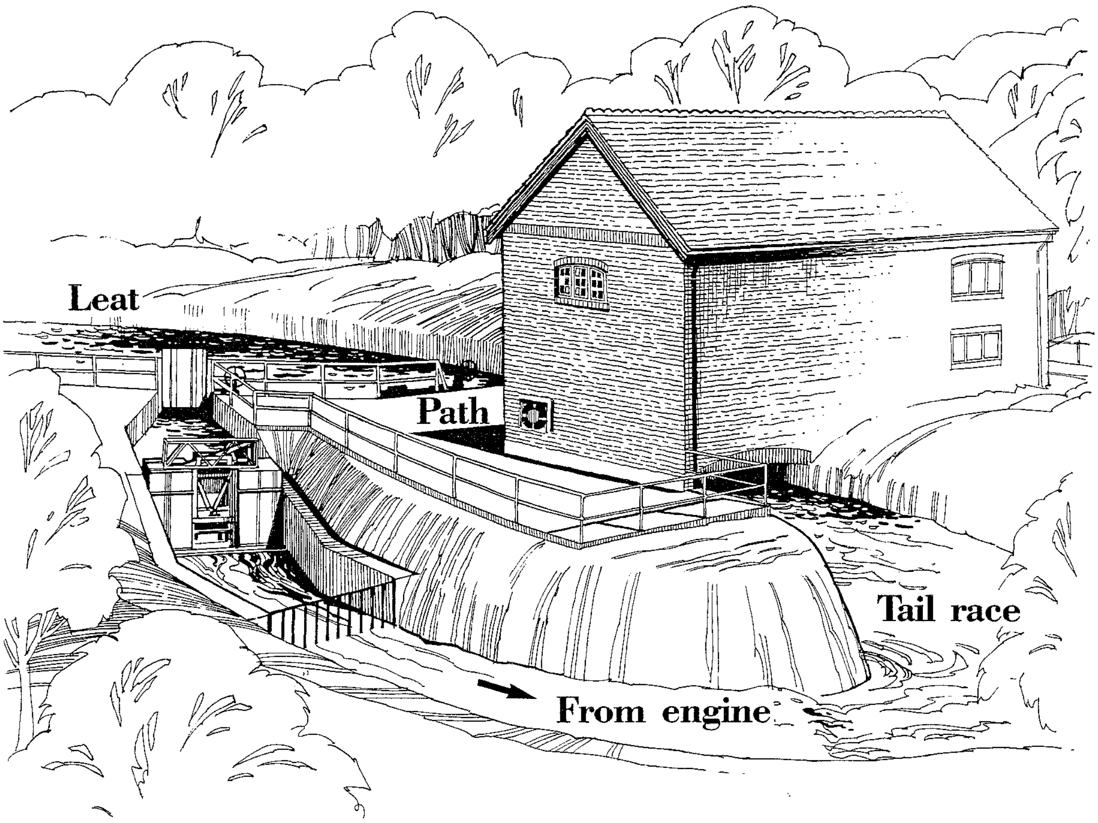
THE AUR WATER ENGINE



Objectives

The objectives of this study were:

- to set up a reliable method of recording the operating characteristics of the AUR water engine in real river flow conditions
- to reconcile the data obtained with the results achieved when operating the machine under simulated conditions in a laboratory test rig
- to carry out an economic assessment of the AUR water engine.

Contractor's Report

Reference No. ETSU SSH 4065
The AUR Water Engine

Contractor

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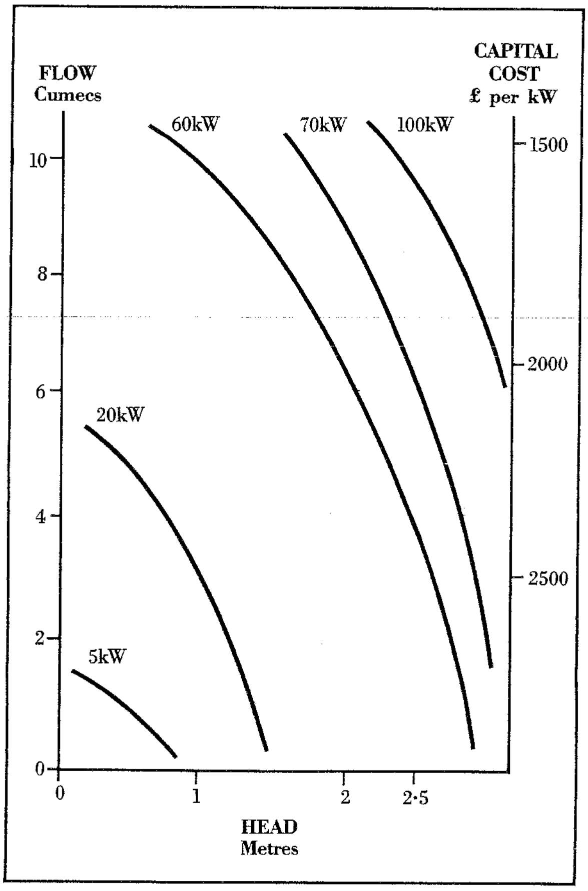
RENEWABLE ENERGY

Department of Energy
First Issued April 1991

Main Conclusions

- This study has shown that the AUR Water Engine can be operated over an extended period without serious mechanical failure.
- There is a wide variation in conversion efficiency depending upon conditions of flow. The mean overall efficiency during the test programme was measured at 55%.
- The investigations confirm the acceptability in principle of the horizontal gate valve. However, the power to operate the gate and the water loss during change-over must be significantly reduced if the overall efficiency is to be improved.



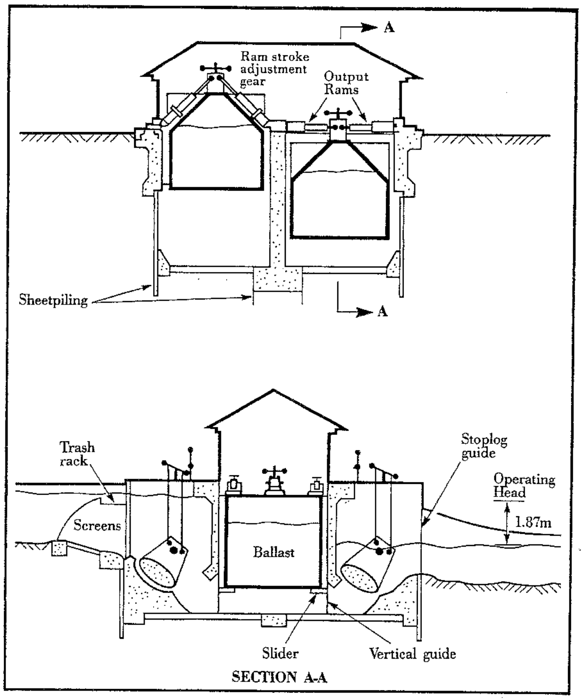
Predicted head/flow/cost relationships

- Environmental objections to the use of oil hydraulics for this type of machine are not seen as an adverse marketing factor at the moment but may influence future design.
- The capital cost of a 70kW prototype machine is estimated to be £275,000. This study assumes that this figure may be reduced to £137,000 for a production machine and on this basis predicts power costs of 4.84p/kWh for an annual return of 13% on capital invested. These costs do not include the provision of leats or weirs. They do, however, include both the costs of civil works associated with the installation of the engine in an existing weir or in a new weir where it replaces some sluices, and the cost of housing the generator and control equipment.

General Introduction

The most effective method of producing useful energy from hydro-power sources with heads greater than 10m is to use water turbines. At low heads (say less than 5m), this method becomes increasingly uneconomic due to the high cost and relatively low efficiency of such machines. With water resources at high heads becoming less readily available, however, attention has turned to the possibility of utilising river sites with heads of 3m or less, using machines other than the turbine or water-wheel.

The AUR water engine is an example of such a device, designed to harness flows down to 0.5m head. This engine, developed by AUR Hydropower Ltd., was first demonstrated in a single chamber form in 1978. A study to optimise the design was started in 1980 at Salford University, using first a single chamber model and later an improved twin chamber unit, designed to produce a maximum output of 2kW. These studies were supported by a grant of £50,000 from the Department of Energy. This work confirmed the potential capability of the engine to extract useful energy from low hydraulic heads up to 0.8m. The restrictive nature of the laboratory rig prevented a sound conclusion being reached on the question of economic viability. In 1984, therefore, the machine was transferred to the site at Gibbons Mill, near Billingshurst, Sussex, and the study reported here was carried out under true 'run of river' conditions.



Commercial Aur water engine general arrangement

Description of the engine

The AUR water engine is a reciprocating machine, using water with a head up to 3m to raise and lower alternately two floats by the admission and discharge of water, into and out of chambers in which the floats are housed. The floats, constrained to move vertically clear of the walls of the chambers, are suspended from pivotal headgear connected to hydraulic rams. During each stroke of the machine, the floats exert a variable force on the hydraulic rams, but the changing geometry of the headgear converts this into a steady hydraulic pressure. This is further smoothed by use of a hydraulic accumulator in the high pressure circuit. The high pressure fluid can be used through a hydraulic motor to drive a generator or a pump.

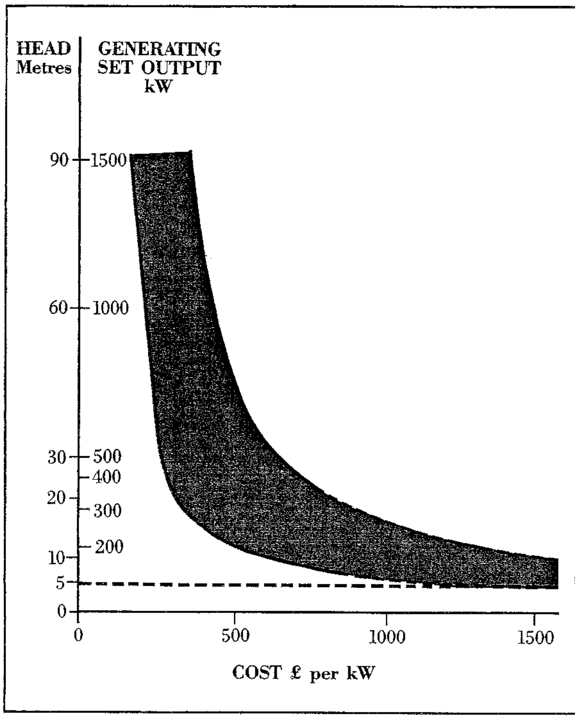
Gates in the upstream and downstream walls of the chambers control the inflow and discharge of water. These are hydraulically operated by a slave cylinder in an ancillary circuit supplied from the main hydraulic circuit.

The concept of a float-operated machine is not new, but the unique feature incorporated in this design is primarily the changing geometry headgear. This converts the variable force exerted by the float into a steady force on the hydraulic ram and enables the machine to deliver power when the float is rising or falling. The provision of two chambers, each equipped with a float and a large gate, enhances the ability of the machine to extract power from very low heads.

An important aspect of the machine is that the rate of working is automatically controlled by the energy demand. When the load increases, the oil pressure in the hydraulic circuit drops slightly, thus allowing the floats to speed up and pass an increased amount of water. Conversely, as the load falls so the hydraulic pressure increases, movement of the floats is slowed down and the water flow is reduced.

Method

- The first stage of the study examined the machine's performance across the available range of hydraulic heads with the main control elements, namely the hydraulic motor swash plate angle and the machine stroke, fixed as reference values. The performance of the existing, purpose designed, microprocessor unit was monitored and equipment suitable for automatically logging the water conditions and the machine performance was installed.
- The second stage tested the machine performance for a range of settings of the hydraulic motor swash plate angle and the machine stroke over a range of hydraulic heads. In this way, all equipment was tested over a full operational range prior to a fully instrumented extended test run.
- The third stage of testing comprised a fully instrumented extended test run with the machine set up for optimum output and efficiency.
- Data recorded included date, time, hydraulic system pressure, swashplate angle, electrical power output, engine strokes/minute, length of stroke, upstream and downstream water levels and water levels in the float chambers.
- Water flow through the engine and leakage loss through the gates were calculated from observed measurements of flow across the weir.
- Water levels in the leat upstream and downstream of the machine and within the float chamber were checked from time to time by observation of gauging posts.
- A cost 4.8 p/kWh was calculated on the assumption that the cost of a production machine could be reduced to £137,000 and that an annual charge, equivalent to 13% of the capital costs, could cover annual amortisation, operation, maintenance and other charges.

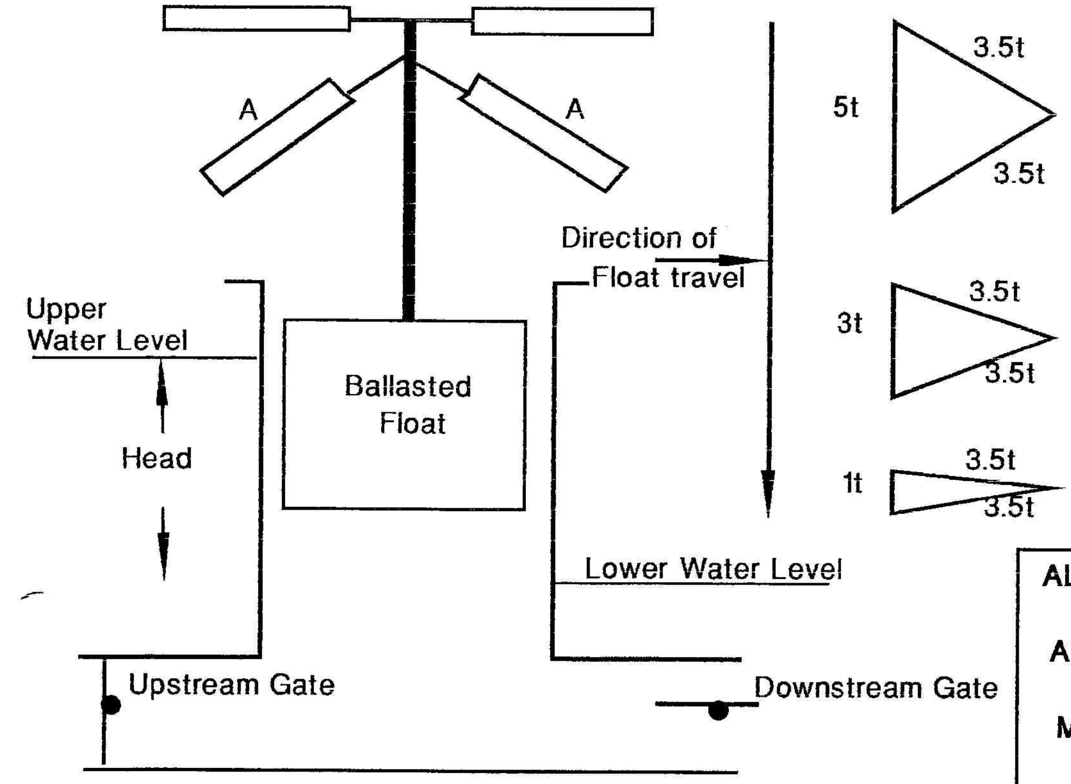


Capital cost envelope—water turbines

A U R HYDROPOWER LTD

WATER ENGINE FORCE DIAGRAMS

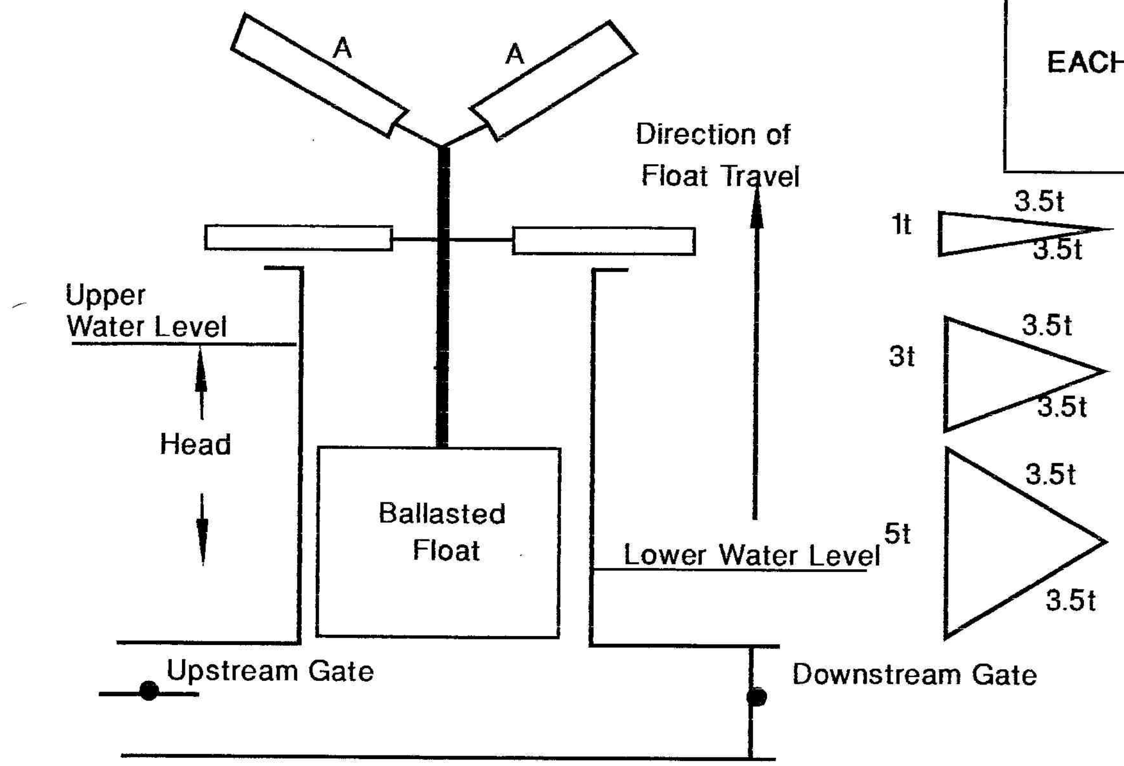
(Primary power output is Hydraulic Energy (oil) in the range 3-5000 psi.)



Force Diagram follows the Active Rams (A A)

FALLING WATER IN CHAMBER

ALTERATION OF THE RAM ANGLE WITH FLOAT MOVEMENT ENSURES A CONSTANT RAM PRESSURE THROUGHOUT EACH STROKE, UP OR DOWN.



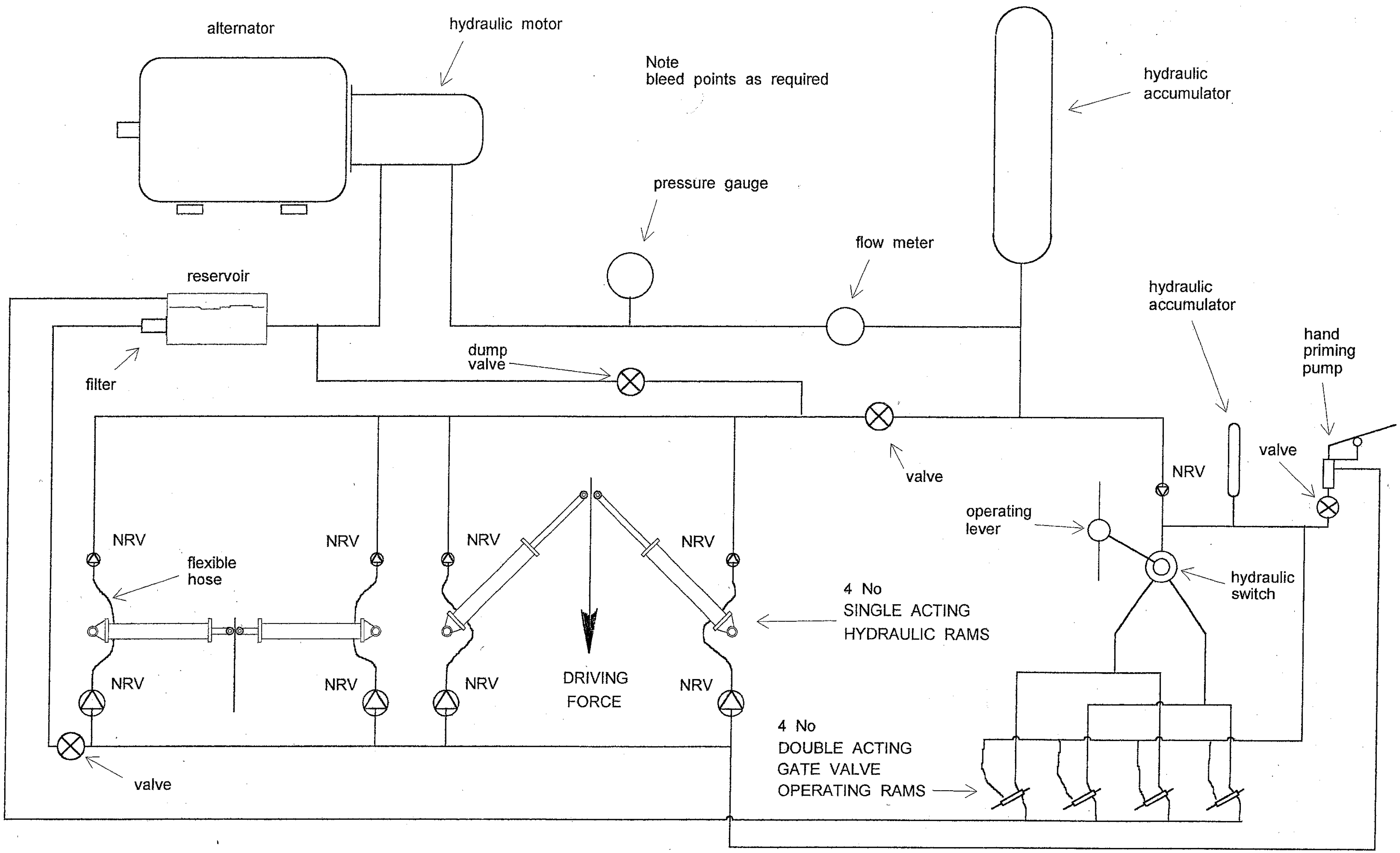
Force Diagram follows the Active Rams (A A)

RISING WATER IN CHAMBER

PATENTS HELD

India	160334
Ireland	54985
New Zealand	207271
Pakistan	129002
Philippines	22197
UK	2138509
US	4691514

AFS/as Feb 1996



AUR HYDROPOWER LTD 19TH FEBRUARY 1996	AUR WATER ENGINE HYDRAULIC SYSTEM

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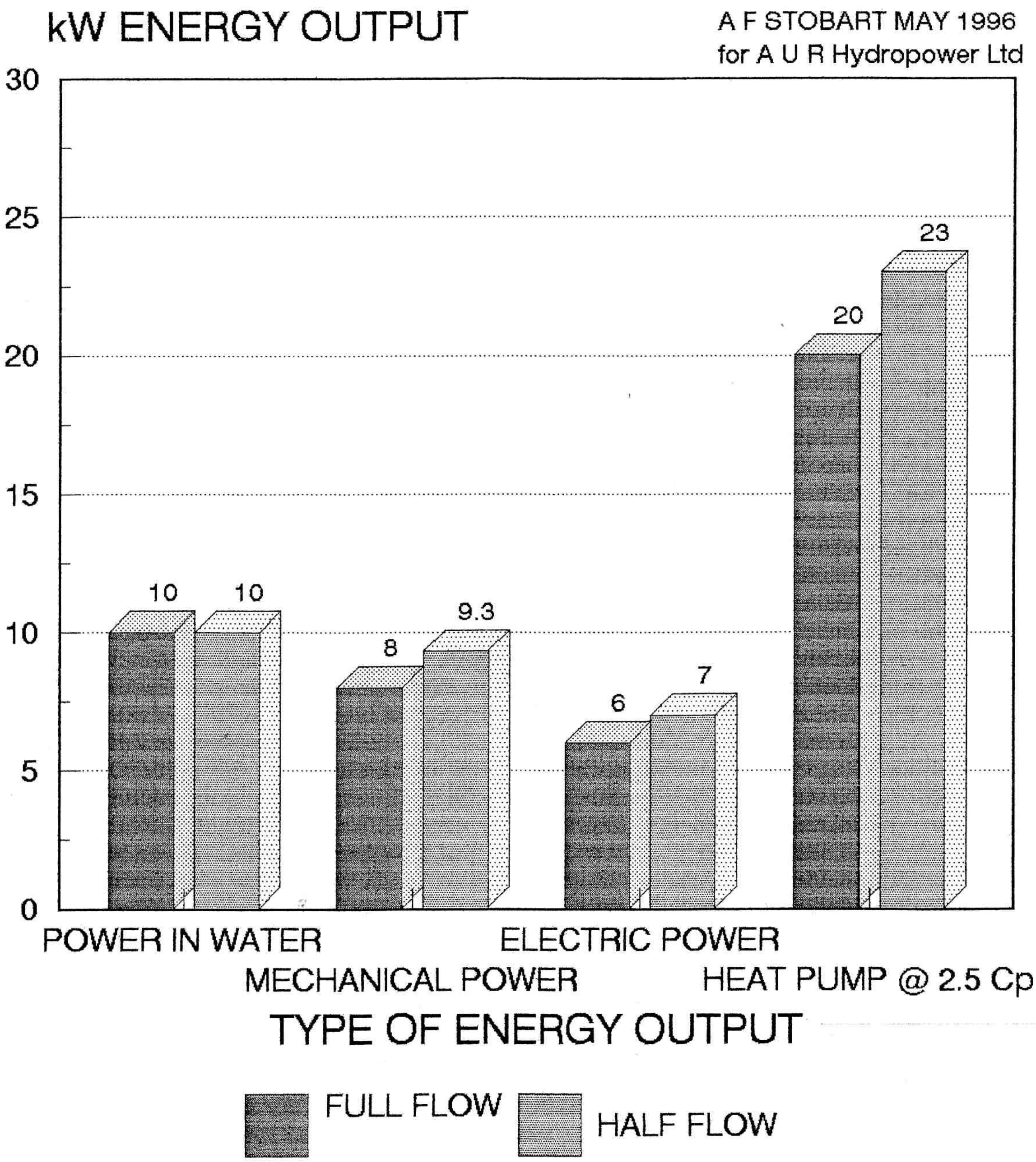
WATER ENGINE
ENERGY OUTPUTS
FROM 1 CUMEC OVER 1 M HEAD



INDICATIVE DATA ONLY
NOT FOR COST ESTIMATING